Eco. Env. & Cons. 30 (4) : 2024; pp. (1653-1660)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i04.032

Effect of Different Brinjal Rootstocks on Growth and Yield of Grafted Tomato Cultivars

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(Received 24 May, 2024; Accepted 19 July, 2024)

ABSTRACT

Tomato (*Solanum lycopersicum* L.) is a significant vegetable crop, popularly known for its utilization as an indispensable kitchen vegetable bearing high nutritional value and inherent health benefits. The world's rising population and mankind's increased demand for tomato production has leveraged the use of Grafting tomatoes, a technique that not only allows for higher yields, but also favors pest resistance and reduced crop losses due to adverse environmental conditions. Thus, owing to the importance of tomato cultivation in today's world and the beneficial effects incurred by grafting, the field experiment was carried out during 2023-24 at Loyola farm, old Alwal, Secunderabad to evaluate the grafted tomato for growth and yield. The field experiment was conducted in Factorial Randomized Block Design with three replications with two Brinjal rootstocks and six tomato scions. The following characteristics of grafted and non-grafted were recorded. Plant height, No of Branches, Days to 50 % Flowering, No of Flowers per cluster, Number of fruits per plant, Average fruit weight, Fruit yield per plant, plot and hectare. The results showed that highest Plant height, more no of Branches, less Days to 50 % Flowering, more no of Flowers per cluster, more number of fruits per plant, Average fruit weight, Fruit yield per plant , plot and Hectare were improved by grafting with *Solanum torvum* followed by Utkarsha brinjal hybrid. The lowest values were recorded in non-grafted plants. Apositive effect of grafting was recorded with *Solanum torvum* followed by Utkarsha which were used as rootstock. Among all grafted combinations abhiman grafted on solanum torvum (R1S2), and US-440 grafted on Utkarsha recorded highest yied (89.38 t/ha, 68.69 t/ha) respectively. These results showed that grafting could be an advantageous alternative in tomato production.

Key words: *Grafting, Root stock, Scion, Solanum torvum, Solanum lycopersicum, Utkarsha*

Introduction

Tomato (*Solanum lycopersicum* L.) is a significant vegetable crop and is well known for its utilization as fresh vegetable and processed foods such as tomato paste, tomato juice, ketchup, canned tomatoes that provide high nutritional value for its consumers. The health benefit of tomatoes makes it one of the most commercially viable commodity which can be a component of year round vegetable cultivation (Noopur *et al.,* 2021) as well as food and nutrition security (Noopur *et al*., 2019). Tomatoes are universally treated as 'Protective Food' since they are very rich in minerals, vitamins, antioxidants, essential amino acids, sugars, and dietary fibers, which are important ingredients for chutney, pickles, ketchup, soup, juice, puree, etc. (Sekhar *et al.,* 2010). Fresh tomato fruit is in high demand throughout the coun-

try all-round the year. Hence, there is a continuous need to strengthen the crop improvement programs in tomatoes tocater the present-day needs of farmers and consumers as well. Use of grafted seedlings became a widespread agricultural practice in many parts of the world (Pogonyi *et al.* 2005). Vegetable grafting, primarily for tomatoes and watermelon, recently increased (Atasayar, 2006). Khah *et al*. (2006) showed that tomato grafting on suitable rootstocks has positive effects on cultivation performance. Researchers consider that grafted plants, which provide increased yield and, consequently, higher profit, can be of value to farmers. Furthermore, in many of the most economically important vegetable crops such as tomato, increases in fruit yield are typically a result of increased fruit size (Pogonyi *et al*. 2005). Owing to their utilization of the vigorous root system of the rootstocks, grafted plants usually show increased uptake of water and minerals when compared with self-rooted plants (Lee, Oda, 2003). Research has shown that possible mechanisms for increased yield are likely the result of increased water and nutrient uptake by vigorous rootstock genotypes. The cultivated Brinjal and wild Brinjal (*Solanum torvum*) were tested as rootstocks, using the commercial tomato US 440, Abhiman, Sahoo, Sweakar, Ayaan and Arka abhed used as scion. The study reported higher yield from the grafted plants than nongrafted. The purpose of this study was to investigate possible positive effects of grafting and use of different rootstocks on the growth and fruit yield attributes of tomato plants.

Materials and Methods

The field experiment was conducted at the Loyola farm, Hyderabad, Telangana. The climate of Hyderabad falls under tropical semi-arid. The average rainfall is about 800 mm. and well-drained Sandy loam soil was selected for the experiment which had uniform soli depth. The experiment was conducted with 18 treatments in Factorial Randomized Block Design (RBD) with three replications during Rabi 2023 at Loyola Farm, Hyderabad. The experimental Plant material for grafting, commercial tomato cultivars US-440, Abhiman, Sahoo, Sweakar, Ayaan and Arka abhed were used as scions and *Solanum torvum* and Utkarsha were used as root stocks.

Raising of rootstocks and scion seedlings

Seeds of *Solanum torvum* sown one month earlier than scion seeds. To overcome the problem of uneven germination, the rootstock seeds sown in 99 cells pro-trays containing sterilized coco-peat to avoid the problem of uneven germination. *Solanum torvum* seeds were soaked in 100 ppm GA_3 solutions for 12 hours. Seedlings were drenched with water soluble 19:19:19 NPK (5 g/1 litter water) ten to fifteen days after germination of seedlings for good growth. Seedlings were watered whenever necessary, and all plant protection measures were taken to ensure healthy and vigorous seedling growth. The rootstock seedling takes 60 to 65 days and scion seedlings ready for grafting in 25-30 days after sowing.

Grafting: Six tomato cultivars like US-440 (F1Hybrid), Abhiman, Sahoo, Sweakar (F1Hybrid), Ayaan (F1Hybrid), Arka Abhed (F1Hybrid) were grafted onto *Solanum torvum* and Utkarsha rootstock. Cleft grafting, as per (Oda 1995), was conducted in a greenhouse under shaded conditions to shield the grafted plants from excessive sunlight and wind, preventing wilting. The rootstocks were trimmed at the top, creating a 2.5 cm slit at the centre for the scion insertion. The upper portion of the scions were pruned to 1- 3 leaves and 2.5 cm wedge cut at its base, facilitating its insertion into the rootstock's slit Rootstocks, longitudinal cut was made 1.5 cm. Thereafter, scion was inserted into the rootstock and graft unions were wrapped with plolythin strip to improve stability, reduce chance of infection, and ensure vascular binding. For grafting, 17 to 19 mm stem girth seedlings of both scion and rootstocks. The age of rootstock was 60 to 65 days (3-4 true leaves) and scion age was 25-30 days (3-4 true leaves). Grafting was carried out in the morning and evening hours under moist chambers made up with transparent polythene of 100-micron thickness. Non grafted seedlings were used as a control. In line with (Marsic and Osvald's 2004) recommendations, the grafted plants were placed in an environment with a temperature of 28-30 °C and a humidity level exceeding 95% for three days. This facilitated healing and bolstered survival rates. Subsequently, the humidity gradually decreased, while light intensity was augmented to create optimal growth conditions, a foliar spray of water was found to be effective in enhancing the survival of the grafted plants to avoid wilting of plants. Sampling was done by

selecting five randomly from each net plot for each treatment and tagged for recording plant growth parameters like, plant height (cm), number of primary branches, days to 50% flowering, No of Flowers per cluster, Number of fruits per plant , Average fruit weight , Fruit yield per plant , Fruit yield per plot and Fruit yield per Hectare. Statistical analysis was done for various parameters by using analysis of variance procedure for Factorial randomized block design procedure given by (Panse and Sukhatme, 1978). The fruit characteristics of grafted plants were compared with those of nongrafted plants. The results showed that the fruit index (diameter/length), number of fruits/trusses, and fruit weight were significantly influenced by grafting.

Results and Discussion

The growth and yield contributing traits of six tomato scions grafted with *Solanum torvum* and Utkarsha plants were compared with those of nongrafted plants. The data on the mean performance of hybrids for growth, yield and yield contributing characters are presented in Table 1 & 2.

Effect of different rootstock on the vegetative growth

Plant height: Grafted plants may respond differently to environmental conditions such as temperature, light intensity, and soil moisture. These factors can affect plant height either directly through physiological responses or indirectly through their influence on overall plant health and growth. Data in Table 1 showed that plant height was more in (R_1S_2) Abhiman grafted onto *Solanum torvum* rootstock (148.84 cm) followed by (R_1S_1) US-440 grafted with Utkarsha rootstock (134.28 cm) at final harvest. On the other hand, the lowest recorded of these characters were resulted in non-grafted (R0S6) Arka abhed (99.40 cm) tomato plants. The increased plant height was noticed in most of the grafted eggplants which were more vigorous than the non-grafted ones (Khah, 2012). (Bharathi *et al.,* 2021) also observed Positive effects in the plants grafted with *Solanum torvum* rootstock.

No of primary branches: Among the different graft combinations,(R_1S_2) Abhiman tomato grafted on to *Solanum torvum* rootstock recorded the highest number of Primary branches at final harvest (15.64) but the lowest number of branches were observed among the grafted plants noticed in (R2S6) Arka abhed with Utkarsha rootstock (8.20) (Table 1). It might be due to the strong and deep root system of rootstock which is able to absorb water and minerals content in aerial plant parts may be attributed to the physical characteristics of the root system, such as lateral and vertical development. The vigorous root system of the rootstock enhanced better growth of scion which resulted in a greater number of branches in grafted plants (Salehi-Mohammadi *et al*., 2009). These results are agreement with Balaji *et al*. (2021), Yashwanth *et al.* (2021) and Rajashree *et al.* (2021).

Flowering

Fifty percent flowering: The study revealed notable differences in the timing of flowering among various tomato plant treatments. Non-grafted (R_0S_3) Sahoo demonstrated the earliest onset of flowering at (25.70) days which was at par with non-grafted (R_0S_5) Ayaan (28.80), (R_0S_1) US 440 (29.60) and (R_0S_2) abhiman (30.40) demonstrated, Surprisingly, (R_1S_2) Abhiman grafted onto *Solanum torvum* rootstock exhibited an accelerated flowering process, with 50% flowering occurring in a shorter timeframe, approximately (37.60) days, followed closely by (R_1S_1) 440 grafted onto *Solanum torvum* (39.20) days and (R_1S_3) Sahoo grafted onto *Solanum torvum* (41.40) days. Among the Tomato scion grafted on Utkarsha, (R_2S_2) Abhiman grafted on Utkarsha (32.00) took less number of days for fifty percent flowering which was at par with (R_2S_5) Ayaan grafted on Utkarsha (33.20) days where as highest number of days were recorded with (R_2S_3) Sahoo grafted on Utkarsha (36.67). In commercial cultivation, early flowering is a crucial attribute, indicating the time taken for plants to initiate flowering and is highly desirable when coupled with high yield. Research by Nkansanh *et al.* (2013) and Kumar *et al*. (2017) observed earlier flowering in grafted plants compared to non-grafted ones. This finding underscores the potential of grafting techniques to accelerate the flowering process, which is advantageous for maximizing crop yields within shorter growing periods.

Number of flowers per cluster: No of flowers per cluster was significantly affected by grafting, grafted plants bloom a greater number of flowers per cluster than non-grafted plants.grafted with of flowers per cluster were observed in (R_1S_2) Abhiman grafted on *solanum torvum* (8.20) which was at a par with (R_1S_5) Ayaan grafted with *Solanum torvum* (7.50), Among the tomato plants grafted with Utkarsha,

Maximum number of flowers were observed in (R_2S_2) Abhiman grafted on Utkarsha (7.50) followed by (R_1S_4) Sweakar grafted on Utkarsha (6.93) while the minimum number of flowers were noted in non-grafted (R_0S_3) Sahoo (4.93). This might be attributed due to the altered mode of gene expression so as to cause morphological and physiological changes in scion (Zhanga *et al.* 2008). Sex expression and flowering are controlled by plant hormones. The root-stock-scion combination may alter the number of hormones produced in grafted plants which resulted in maximum number of flowers in grafted plants than non-grafted Salehi-Mohammadi *et al*. (2009). These results agreed with the findings of Khah *et al*. (2006) reported highest numbers of flowers per cluster in tomatoes.

Yield parameters

Number of fruits per plant: The yield parameters of grafted tomato were shown significant difference

Table 1. Performance of grafted and non-grafted tomato plants for growth

Treatments	Plant height	No of Primary branches
R_0-Control	90.13	9.00
R_1-*Solanum torvum*	126.30	12.13
R_2-Utkarsha	112.96	10.46
SEm±	0.61	0.06
CD at 5%	1.76	0.12
S_1: US 440	121.33	13.00
S_2: Abhiman	120.00	12.86
S_3: Sahoo	102.60	8.86
S_4: Sweakar	108.00	10.40
S_5: Ayaan	107.46	10.00
S_6: Arka abedh	99.4	8.06
SEm±	0.86	0.08
CD at 5%	2.14	0.25
R_0S_1: US 440	101.28	11.00
R_0S_2: Abhiman	94.44	10.20
R_0S_3: Sahoo	80.68	7.40
R_0S_4: Sweakar	91.24	9..60
R_0S_5: Ayaan	89.20	8.64
R_0S_6: Arka abedh	84.16	7.28
R_1S_1: US 440 grafted on *Solanum torvum*	134.28	14.86
R_1S_2: Abhiman grafted on *Solanum torvum*	148.84	15.64
R_1S_3: Sahoo grafted on *Solanum torvum*	118.26	10.80
R_1S_4: Sweakar grafted on *Solanum torvum*	120.28	11.26
R_1S_5: Ayaan grafted on *Soum torvum*	126.44	11.64
R_1S_6: Arka abedh grafted on *Solanum torvum*	110.20	8.86
R_2S_1: US 440 grafted on Utkarsha	128.60	13.20
R_2S_2: Abhiman grafted on Utkarsha	116.84	12.80
R_2S_3: Sahoo grafted on Utkarsha	109.26	8.44
R_2S_4: Sweakar grafted on Utkarsha	112.60	10.40
R_2S_5: Ayaan grafted on Utkarsha	106.80	9.80
R_2S_6: Arka abhed grafted on Utkarsha	103.80	8.20
SEm±	1.49	0.15
CD at 5%	**3.98**	**0.38**

R1 - Control: S1 -US 440, R1S1 -US 440 grafted on *Solanum torvum*, R2S1 -US 440 grafted on Utkarsha; **R2 - *Solanum torvum*:** Root stock: S2 – Abhiman, R1S2 -Abhiman grafted on *Solanum torvum,* R2S2 -Abhiman grafted on Utkarsha; **R3 - Utkarsha Root stock:** S3 –Sahoo, R1S3 -Sahoo grafted on *Solanum torvum*, R2S3 -Sahoo grafted on on Utkarsha; S4 – Sweakar, R1S4 -Sweakar grafted on *Solanum torvum*, R2S4 -Sweakar grafted on Utkarsha; S5 –Ayaan, R1S5 -Ayaan grafted on *Solanum torvum*, R2S5 -Ayaan grafted on Utkarsha; S6 -Arka abedh, R1S6 -Arka abedh grafted on *Solanum torvum*, R2S6-Arka abhed grafted on Utkarsha.

over non-grafted tomato plants. Maximum number of fruits were observed in (R_1S_2) Abhiman grafted on *Solanum torvum* (84.86) which was at a par with (R_1S_5) Ayaan grafted on *Solanum torvum* (82.40), (R_1S_4) and (R_1S_1) US 440 grafted on *Solanum torvum* (80.00). Among the different tomato scions grafted with Utkarsha, Maximum number of fruits were obtained with R_2S_1 US-440 grafted on Utkarsha (71.60), which was at a par with (R_2S_4) Sweakar grafted on Utkarsha (68.86), and (R_2S_2) Abhiman grafted on Utkarsh (66.83). The lowest number of fruits were observed in non-grafted R_0S_5) Ayaan tomato plants (61.53) Grafted plants likely yield more marketable fruit than non-grafted ones due to the employment of robust rootstocks. These rootstocks are presumed to enhance the levels of cytokinin and gibberellin within the scion, thereby augmenting fruit production on the plants. These results are analogous to the findings of Radhouani and Ferchichi (2010), Ibrahim *et al.* (2014), Rahmatian *et al.* (2014), El-Gazzar *et al*.

Table 2. Performance of grafted and non-grafted tomato plants for yield attributes

Treatments	Days to 50 % Flowering	No of flowers Per cluster	No of Fruits per plant	Avg Fruit weight	Fruit yield per plant (Kg)	Fruit yield per Plot (Kg)	Fruit yield per ha (t)
R_0	30.60	6.28	49.66	55.85	2.76	44.19	34.10
R_1	42.62	7.16	77.63	77.73	6.04	96.66	74.58
R_2	34.99	6.58	62.40	69.01	4.33	69.42	53.57
SEm±	0.70	0.04	0.35	0.37	0.02	0.39	0.30
CD at 5%	2.02	0.11	0.82	1.08	0.05	0.92	0.67
S_1	33.60	6.63	73.40	68.97	5.13	82.1	63.35
S_2	34.11	7.60	68.13	74.34	5.18	82.88	63.95
S_3	34.59	5.98	54.06	63.17	3.59	57.57	44.42
S_4	37.18	6.90	65.73	62.75	4.21	67.49	52.08
S_5	36.86	6.93	61.53	69.52	4.26	68.23	52.65
S_6	40.09	6.00	57.26	66.43	3.89	62.27	48.04
SEm±	0.99	0.05	0.49	0.53	0.04	0.55	0.42
CD at 5%	2.86	0.16	1.23	1.53	0.11	1.59	1.13
R_0S_1	29.67	6.13	67.83	48.31	3.28	52.41	40.44
R_0S_2	30.40	7.12	52.80	60.74	3.21	51.31	39.59
R_0S_3	25.70	5.45	37.67	49.57	1.86	29.82	23.10
R_0S_4	33.70	6.74	49.60	56.13	3.02	48.32	37.28
R_0S_5	28.83	6.50	46.90	64.48	2.78	44.48	34.32
R_0S_6	35.40	5.80	43.40	55.91	2.43	38.82	29.95
R_1S_1	39.20	7.36	80.00	81.13	6.56	104.88	80.93
R_1S_2	37.67	8.20	84.86	86.03	7.24	115.84	89.38
R_1S_3	41.40	6.74	71.40	79.64	5.69	90.98	70.20
R_1S_4	43.50	7.12	76.66	69.84	5.35	85.60	66.05
R_1S_5	45.83	7.50	82.40	74.18	6.14	98.27	75.83
R_1S_6	48.20	6.27	69.86	75.56	5.27	84.39	65.41
R_2S_1	32.00	6.48	71.60	77.49	5.56	89.02	68.69
R_2S_2	34.33	7.50	66.83	76.25	5.09	81.50	62.88
R_2S_3	36.67	5.89	53.20	60.31	3.24	51.91	40.06
R_2S_4	34.33	6.93	68.86	62.29	4.28	68.56	52.90
R_2S_5	35.97	6.80	55.43	69.90	3.87	61.96	47.81
R_2S_6	36.67	6.00	58.6	67.84	3.98	63.61	49.08
SEm±	1.72	0.09	0.86	0.92	0.07	0.95	0.73
CD at 5%	**4.95**	**0.23**	**1.84**	**2.14**	**0.18**	**2.45**	**1.86**

R_0S_1 -US 440; R_0S_2-Abhiman; R_0S_3-Sahoo; R_0S_4-Sweakar; R_0S_5-Ayaan; R_0S_6-Arka abhed; R_1S_1-US 440 grafted on *Solanum torvum* ; R_1S_2 - Abhiman grafted on *Solanum torvum*; R_1S_3 -Sahoo grafted on *Solanum torvum*: R_1S_4 -Sweakar grafted on *Solanum torvum*; R_1S_5 -Ayaan grafted on *Solanum torvum*; R_1S_6 -Arka abedh grafted on *Solanum torvum*; R_2S_1-US 440 grafted on Utkarsha; R_2S_2 -Abhiman grafted on Utkarsha; R_2S_3 - Sahoo grafted on Utkarsha, R_2S_4 -Sweakar grafted on Utkarsha; R_2S_5 -Ayaan grafted on Utkarsha; R_2S_6-Arka abhed grafted on Utkarsha.

(2016), Soe *et al.* (2018), Hossain *et al.* (2019), Sharma *et al*. (2019), Singh *et al*. (2019), Dahake *et al*. (2020).

Average fruit weight: The findings concerning the average fruit weight indicated notable distinctions among all the treatments. Average fruit weight of grafted and non-grafted tomato plants varied from (48.31 g to 86.03 g). Greatest Fruit weight was noticed in (R_1S_2) Abhiman grafted with *Solanum torvum* (86.03 g) which was at a par with (R1S1) US-440 grafted with *Solanum torvum* (81.13g). Among the different tomato scions grafted with Utkarsha, greatest fruit weight was noticed in R_2S_1 US-440 grafted with Utkarsha (79.49 g) which was at a par with R_2S_2) Abhiman grafted with Utkarsha (76.25 g) lowest fruit weight was noticed in (R_0S_1)US - 440 (48.31 g). Grafted plants absorb elevated levels of nitrogen up to a certain threshold, which promotes robust shoot and leaf growth. This increased growth likely facilitates the synthesis of larger quantities of carbohydrates and enhances protein synthesis, contributing to the development of fruits. Consequently, this process may lead to an augmented number of cells and elongation of individual cells, ultimately boosting fruit size. Bletsos *et al.* (2008), Flores *et al*. (2010), Colla *et al*. (2010b),

Fruit yield per plant: Grafting has a considerable impact on the yield.Grafted plants may have a longer productive lifespan, leading to a more extended harvest period and higher total yield over the season per plant. Among the tomato scions grafted with *Solanum torvum*, (R_1S_2) Abhiman grafted with *Solanum torvum* recorded a notably elevated yield of (7.24 kg), which was on a par with R_1S_1) US-440 grafted with *Solanum torvum* (6.56 kg). Among all the combinations with Utkarsha, (R_2S_2). Abhiman grafted with Utkarsha recorded significantly higher yield (5.56 kg) which was at a par with (R_2S_2) Abhiman grafted with Utkarsh (5.09 kg). Among all the non-grafted tomato plants lower fruit yield per plant was recorded with (R_0S_3) Sahoo (1.86 kg).

Fruit yield per hectare: During crop period, among the various rootstocks utilized, *Solanum torvum* exhibited the highest yield of (74.58 t/ha). Followed by Utkarsha with a yield of (53.57) t/ha. Among the tomato scions used, highest yield was observed with (R_0S_2) Abhiman (63.95 t/ha) and lowest yield was noted with (R_0S_3) Sahoo (50.95 q/ha). The interaction effect of *Solanum torvum* Rootstock and different tomato scion showed a significant difference, During the summer season, the grafting of (R_1S_2) Abhiman onto *Solanum torvum* demonstrated the highest yield, reaching (89.38 t / ha). Following closely behind was (R_1S_1) US-440 Ayaan grafted with *Solanum torvum* combination, yielding (80.93 t / ha). Conversely, the lowest yield was observed with the (R_0S_3) Sahoo (23.10 t/ha).

Grafting tomato onto wild eggplant rootstock, particularly using Solanum torvum, showed significantly higher yields per hectare compared to non-grafted plants. This increase in yield can be attributed to the robust root system of *Solanum torvum*, which promotes greater plant height and vigorous growth, leading to enhanced water and nutrient absorption. The scions chosen for grafting were well-known local varieties or hybrids. The improved yield in grafted plants may be a result of the vigorous root system of the wild rootstock, contributing to increased fruit quantity and quality The rootstocks exhibited a high level of compatibility, achieving a grafting success rate of 95% as documented by Kumar *et al.* (2018) and Singh *et al.* (2020). This compatibility is likely attributable to the deep root systems of the rootstocks, enabling them to absorb substantial quantities of water and nutrients. Consequently, this increased nutrient uptake may lead to heightened production of endogenous hormones compared to plants with their own root systems, as noted by Soe *et al*. (2018), Sharma *et al.* (2019), and Yun *et al.* (2023). Grafted plants, as highlighted by Marsic and Osvald (2004) and Tamilselvi and Pugalendhi (2018), consistently displayed higher yields compared to non-grafted ones. This increase in yield, as observed in tomato plants, can be attributed to the heightened vigor of the scion achieved through grafting with a suitable rootstock, as noted by Romano and Paratore (2000) and Milenkovic *et al.* (2020).

Conclusion

Based on the current field experiments, among the two distinct rootstocks employed, *Solanum torvum* exhibited superior performance across most traits, closely followed by Utkarsha. Among the different combinations (R_1S_2) Abhiman grafted with *Solanum torvum* performed well in plant growth and yield attributes. Both *Solanum torvum* and Utkarsha show promise as rootstocks for grafting tomato plants to enhance growth and yield than non-grafted plants.

Acknowledgement

I wish to offer my salute and express my profound sense of gratitude and sincere regards and heartfelt thanks to members of my advisory committee Dr. M. Rajkumar, Assistant Professor, Department of Horticulture, Annamalai University, Dr. R. Sendhilnathan, Assistant Professor, Department of Horticulture, Annamalai University, Dr. B. Sunil Kumar, Associate Professor, Department of Genetics and Plant Breeding for their intellectual and inspiring guidance, sustained patients and cooperation at each stage of research work.

Conflict of Interest

No conflict of interest

Sources of Funding

No external sources of funding

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